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This book is one of a series designed specifically to teach the concepts of automobile emissions control systems. It is intended to assist the practicing mechanic or the home mechanic to better understand the Positive Crankcase Ventilation Systems which are an integral part of automobiles today. The mechanic's increased knowledge should help him keep "emissions controlled" vehicles operating as designed. Respectable fuel economy, performance and driveability, as well as cleaner air, can be obtained from the automobile engine that has all of its emissions systems functioning properly.

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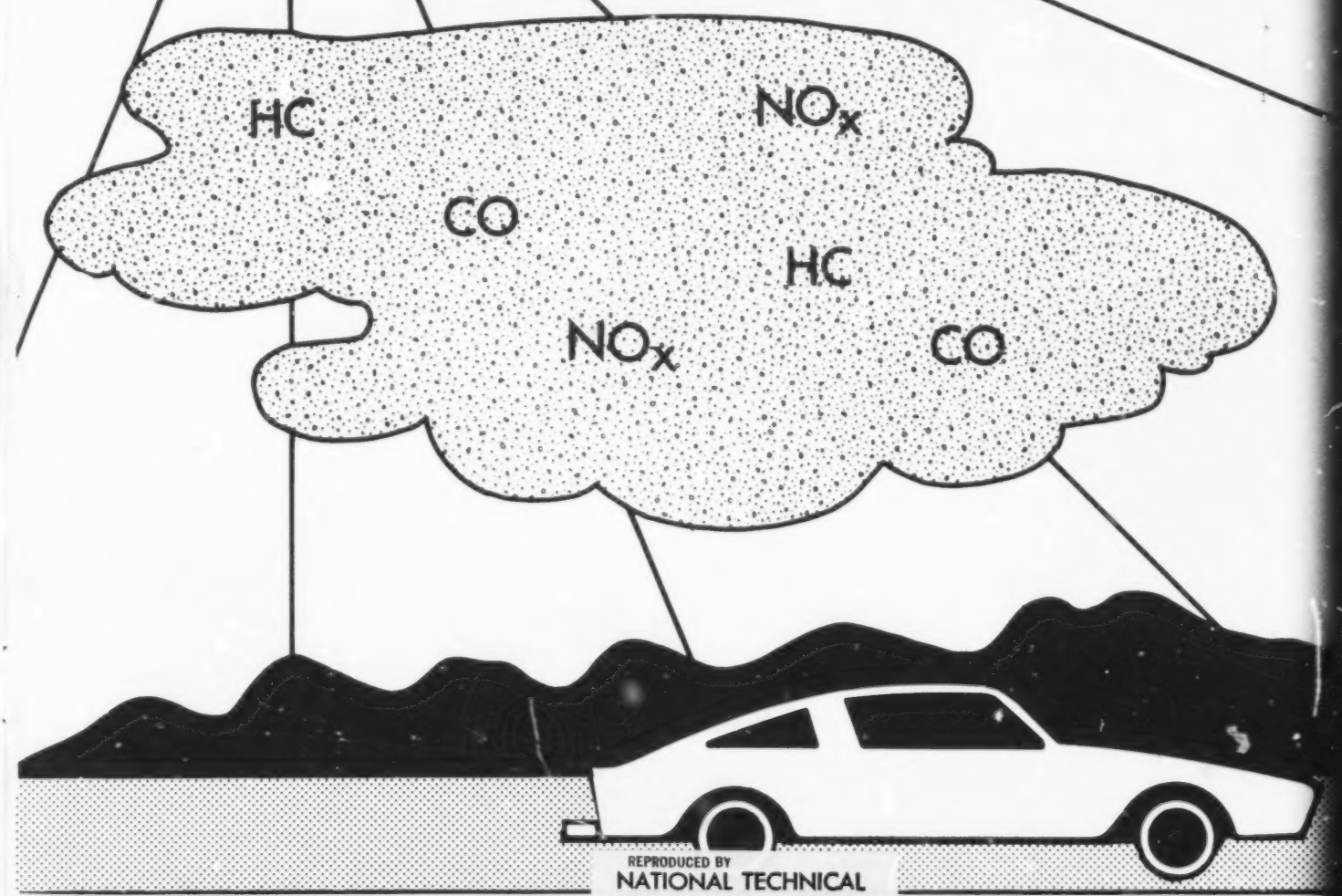

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MOTOR VEHICLE EMISSIONS CONTROL
BOOK ONE
POSITIVE CRANKCASE VENTILATION SYSTEMS

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MOTOR VEHICLE EMISSIONS CONTROL

-- SERIES OF SEVEN BOOKS --

MOTOR VEHICLE EMISSIONS STAFF, COLORADO STATE UNIVERSITY

BOOK ONE - POSITIVE CRANKCASE VENTILATION SYSTEMS

BOOK TWO - THERMOSTATIC AIR CLEANER SYSTEMS

BOOK THREE - AIR INJECTION REACTION SYSTEMS

BOOK FOUR - FUEL EVAPORATION CONTROL SYSTEMS

BOOK FIVE - EXHAUST GAS RECIRCULATION SYSTEMS

BOOK SIX - SPARK CONTROL SYSTEMS

BOOK SEVEN - CATALYTIC CONVERTER SYSTEMS

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A special thanks must be extended to the automotive vehicle equipment and parts manufacturers for their cooperation and assistance in the development of this training material.

INSTRUCTIONS FOR THE USE OF THIS BOOK

This book is one of a series designed specifically to teach the concepts of automobile emissions control systems. Each book is designed to be used as self-instructional material. Therefore, it is important that you follow the step-by-step procedure format so that you may realize the full value of the emissions system which is being presented. The topics are taught in incremental steps and each topic treatment prepares the student for the next topic. Each book is divided into sections which include the introduction, purpose, function, inspection and testing of the emissions system presented.

As you proceed through this series, please begin with book one and read the following books in sequence. This is important because there are several instances where material covered in a given book relies on previously covered material in another book.

To receive the full benefits of the book, please answer the self-evaluation statements related to the material. These statements are separated from the text by solid lines crossing the page. The answers to the statement can be found at the end of the book as identified by the table of contents. You should check for the correct answer after you respond to each statement. If you find that you have made a mistake, go back through the material which relates to the statement or statements.

Fill-in-the-blank statements are utilized for self-evaluation purposes throughout the material. An example statement would appear like this:

The American flag is red, white, and _____.

You would write "blue" in the blank and immediately check your answer at the end of the book.

The material, statements and illustrations should be easy to follow and understand. In several illustrations a small ghost named "VEC" (Vehicle Emissions Control) has been used to make the picture easier to understand.

Upon completion of this series, you should be able to better understand the emissions control systems and devices which are an integral part of automobiles today. Your increased knowledge should help you keep these "emissions controlled" vehicles operating as they were designed to operate. Respectable fuel economy, performance and driveability, as well as cleaner air, can be obtained from the automobile engine that has all of its emissions systems functioning properly.

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INTRODUCTION TO EMISSIONS CONTROL

As we all know emissions systems and devices have been installed on the automobile engine because of the air pollution problem. In order for you to understand these emissions systems and devices you should have a background of the problem. All of the emissions control systems were installed on the engine to reduce just three specific exhaust products. These are known as products of combustion. The three products which the emissions systems are designed to reduce are hydrocarbons, carbon monoxide and oxides of nitrogen.

HYDROCARBONS

Gasoline, like all petroleum products, is made up of hundreds of hydrocarbon compounds. The name "hydrocarbon" has been given to these compounds because they are made up of hydrogen and carbon atoms. This is also the reason hydrocarbons have the abbreviation (HC).

Hydrocarbons are gasoline vapors or raw gasoline itself. One reason hydrocarbon emissions must be controlled is because it is one of the major components of photochemical smog. Photochemical or "Los Angeles" smog forms when hydrocarbons and oxides of nitrogen combine in the presence of sunlight. In order to avoid this smog condition the hydrocarbon emissions from automobiles must be controlled. Hydrocarbons also act as an irritant to our eyes and some are suspected of causing cancer and other health problems.

CARBON MONOXIDE

Another product of combustion that must be controlled is carbon monoxide. Carbon monoxide has the abbreviation (CO). CO is also hazardous to our health when it is mixed with the air we breathe. It can cause headaches, reduce mental alertness and even cause death if enough of it is in the air. Carbon monoxide is also a problem in that it speeds the formation of photochemical smog. For these reasons CO emissions must be controlled.

OXIDES OF NITROGEN

Oxides of nitrogen are the last harmful products of combustion we will discuss. Nitrogen oxides have been given the abbreviation (NO_x). As you already know, oxides of nitrogen and hydrocarbons combine to form photochemical smog. The sunlight which triggers the formation of photochemical smog has another effect on oxides of nitrogen. Some of the oxides of nitrogen are broken down and a gas called ozone is formed. Ozone is a lung and eye irritant and it also deteriorates rubber and affects the growth of vegetation. Since the nitrogen oxides have these effects they must also be controlled.

Now that you are familiar with the emissions which must be controlled let's find out where they originate.

FORMATION OF HYDROCARBONS

Hydrocarbons, you will recall, are fuel vapors or raw fuel. For this reason hydrocarbon emissions will result from any uncontained supply of gasoline. Hydrocarbon emissions also come from the tailpipe. If the automobile engine could achieve "complete combustion," all of the unburned fuel or hydrocarbons would be used up. However, it is impossible for today's automobile engines to achieve "complete combustion." Any time the fuel mixture in the combustion chamber is not completely burned, some hydrocarbons will be emitted from the tailpipe. The two main reasons why hydrocarbons are not completely burned are because of engine misfire and "quench areas." When an engine misfire occurs, none of the raw fuel or hydrocarbons are burned. When this happens they are simply exhausted directly to the atmosphere. Quench areas are places in the combustion chamber where the flame goes out before the fuel is completely burned. Small cavities such as where the head gasket seals the cylinder head to the block is a quench area. Another quench area is located between the top of the piston and the first compression ring. These areas are sources of hydrocarbon emissions.

FORMATION OF CARBON MONOXIDE

Carbon monoxide is partially burned fuel. Carbon monoxide is formed in the combustion chamber whenever there is not enough air to burn all the fuel. This means that whenever a "rich" air/fuel mixture is pulled into the combustion chamber carbon monoxide will be formed. After the flame goes out the carbon monoxide is exhausted through the tailpipe and into the air.

FORMATION OF OXIDES OF NITROGEN

Oxides of nitrogen are also formed in the combustion chamber. These oxides result from the nitrogen which is contained in our air. In some cases combustion temperatures in the automobile engine can exceed 4500°F. At temperatures above approximately 2500°F, nitrogen oxides will start forming. Therefore, if combustion chamber temperatures exceed 2500°F, oxides of nitrogen will be produced and then exhausted to our atmosphere.

Now that you understand how these emissions are formed in the automobile engine, we will see how changes in ignition timing and carburetor adjustment affect the amount of these pollutants.

As you know, changes in timing and carburetion can have a large effect on how an engine performs. These changes in timing and carburetion also can have drastic effects on the amount of pollutants which are present in the automobile's exhaust. The amount of hydrocarbons, carbon monoxide and oxides of nitrogen which are present in the exhaust gases will vary as timing and carburetion adjustments are changed.

IGNITION TIMING

Prior to emissions controlled automobiles, advancing the spark timing was a common practice. Setting the spark timing this way caused the spark plug to fire before the piston reached top dead center. This advanced spark timing allowed the maximum amount of heat energy to be

exerted on the piston. As a result the best performance and fuel economy could be obtained. Unfortunately, this also produced high hydrocarbon and nitrogen oxide emissions levels.

In order to reduce emissions levels, ignition spark timing was retarded. By firing the spark plug after the piston reaches top dead center, not as much of the heat energy is converted to work on the piston. The extra heat energy which is not used on the piston now passes through the exhaust valve and into the exhaust manifold. This keeps the exhaust gas temperatures higher. These higher exhaust temperatures allow burning of the air/fuel mixture to continue in the exhaust manifold. This further oxidation or burning in the exhaust manifold helps to reduce HC and CO emissions.

Another advantage of retarded timing from an emissions standpoint is that combustion temperatures are not as high. This is due to the fact that the maximum combustion pressure will be lower. Since the combustion temperatures will be lower and the formation of oxides of nitrogen depends on temperature, a smaller amount of these pollutants will be exhausted to the atmosphere.

There is one more advantage to using retarded spark timing. As you know, when ignition timing is retarded the engine's idle speed will drop. This decrease in idle speed occurs because less heat energy is applied to the combustion chamber and more heat energy is being supplied to continue the burning process in the exhaust manifold. In order to regain an acceptable idle speed, the throttle plates must be opened wider. This wider throttle plate opening allows more air to pass through the carburetor. This increase in air flow will reduce the amount of residual exhaust gases in the cylinder. This in turn will allow a more burnable mixture which can be made leaner. Since the mixture can be leaner there will be more air in the combustion chamber. As you know, the more air that is made available during combustion the lower will be the HC and CO emissions.

CARBURETION

Adjustments made to the carburetor air/fuel ratio can also have a large effect on the amount of pollutants which come from the automobile engine. When idle mixture settings become richer there is less air present for the combustion process. This lack of air results in an increase in hydrocarbon and carbon monoxide emissions.

When the idle mixture screws are turned in, the amount of fuel is reduced and the mixture becomes leaner. This leaner mixture contains more air and therefore more oxygen is available for more complete burning of the fuel. This results in lower HC and CO emissions levels.

As the idle mixture screws are turned in, the idle air/fuel mixture becomes leaner. If this mixture becomes too lean a "lean misfire" will occur. A "lean misfire" will occur because the fuel is so diluted or thinned out by the air that the mixture will not ignite. This leads t a very large increase in hydrocarbon emissions. This happens because the failure of the mixture to ignite results in that amount of raw fuel being emitted to the atmosphere.

The carbon monoxide emissions decrease when a lean misfire condition is present. Carbon monoxide is partially burned fuel. Since no combustion takes place during a lean misfire condition no CO is formed and the total amount of CO produced by the engine will be less.

A lean misfire usually occurs in one or more cylinders. This condition may also move from cylinder to cylinder while the engine is running. This is caused by the uneven distribution of the air/fuel mixture delivered to each cylinder. This condition occurs mainly because of problems with intake manifold design.

Now you should understand how changes in timing and carburetion adjustment can affect emissions levels. With this knowledge you will be able to understand how each emissions control system we will discuss helps to reduce the air pollution caused by the automobile.

SYSTEM INTRODUCTION

The first automotive emissions control system we will discuss is the positive crankcase ventilation system. The positive crankcase ventilation system, abbreviated PCV system, was developed because automobile engines need to be ventilated. An engine's crankcase must be ventilated if the engine is to operate properly. The crankcase must be ventilated because of a harmful gas known as blowby.

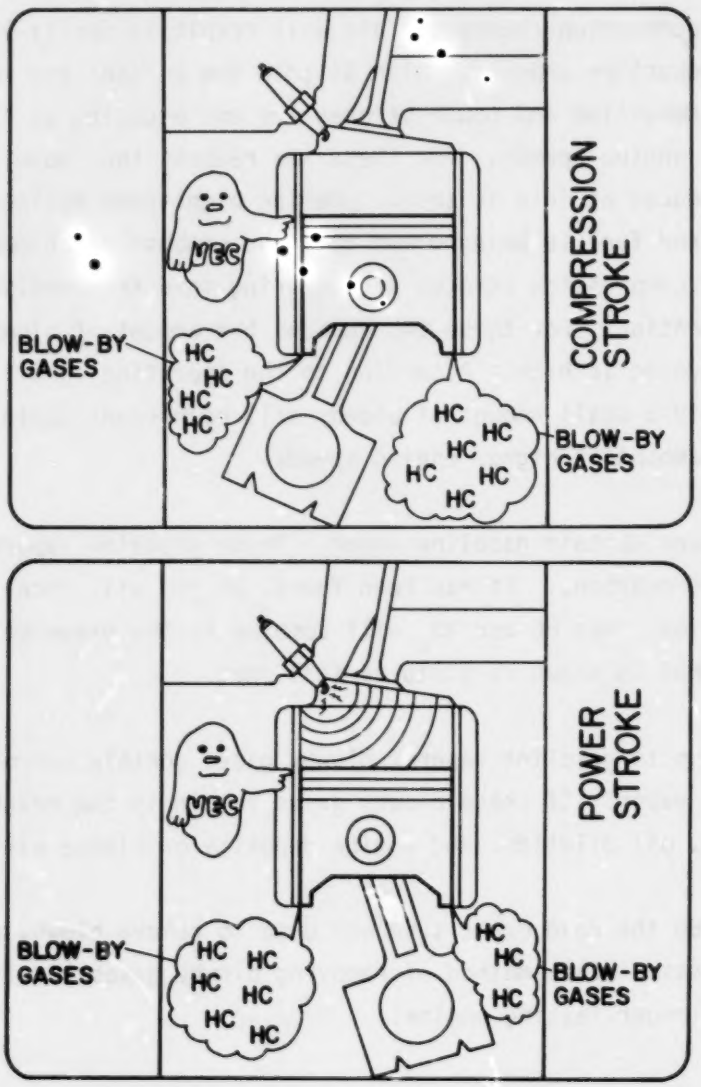

FIGURE 1-1

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Blowby is the name given to those combustion chamber gases which are forced past the piston rings. Blowby occurs any time the engine is running. Gases will be forced past the piston rings whenever a high pressure condition is present in the combustion chamber. This high pressure will exist during the compression stroke and the power stroke. During engine operation harmful pollutants known as blowby gases are forced into the crankcase.

When the engine is idling only a small amount of air and fuel is drawn into the combustion chamber. This will result in farily low pressures in the combustion chamber. Also at idle the pistons are moving slowly and the combustion and power strokes are not occuring as frequently as at higher engine speeds. For these two reasons the amount of blowby gases produced at idle is small. During high speed engine operation more air and fuel is being drawn into the combustion chamber. The power and compression strokes are occuring more frequently during high speed operation. For these two reasons the amount of blowby gases being produced is high. According to the operating conditions of the engine only a small amount of blowby will be present during idle and a larger amount at higher engine speeds.

Blowby gases contain gasoline vapor. These gasoline vapors contain mostly hydrocarbons. It has been found, as you will recall from the introduction, that HC and NO_x will combine in the presence of sunlight to form what is known as photochemical smog.

In addition to gasoline vapors, blowby gases contain corrosive acids and water vapor. If these blowby gases remain in the crankcase, engine corrosion, oil dilution, and engine deposits or sludge will result.

Before 1960 the road draft tube was used to remove blowby gases from the crankcase. This method of removing blowby gases resulted in a cleaner, longer lasting engine.

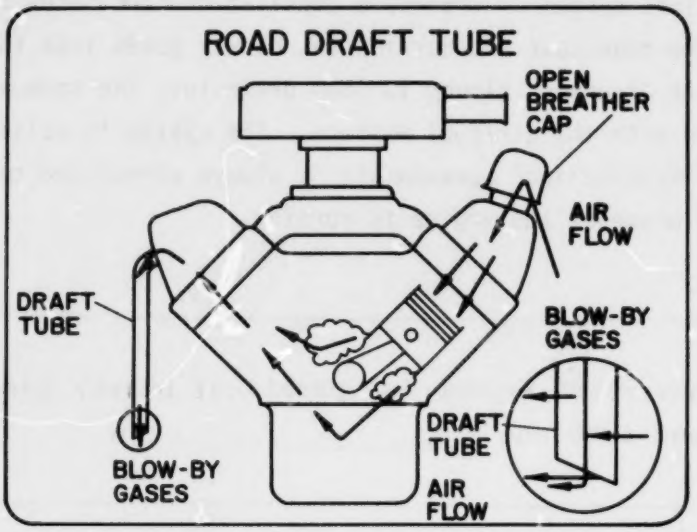

FIGURE 1-2

The road draft tube was connected to the crankcase at one end and the other end extended into the air stream below the automobile. An open oil filler cap was also used with this method of crankcase ventilation. As outside air flowed past the open end of the draft tube a slight vacuum was created. This vacuum would draw fresh air through the open oil filler cap, then through the crankcase and finally out the road draft tube. As the air passed through the crankcase it would pick up the blowby gases and remove them to the atmosphere. Since the vacuum created at the end of the road draft tube was dependent on automobile speed, this type of crankcase ventilation was not effective at speeds below 25 MPH.

It was found that 20% of all hydrocarbon emissions came from the crankcase. These hydrocarbon emissions could be eliminated if the blowby gases were not discharged to the atmosphere.

On most California automobiles manufactured in 1961 and most U.S. automobiles manufactured after 1962 the road draft tube was replaced by a new crankcase ventilation system. This new system was called the Positive Crankcase Ventilation System. Most people call it the PCV

system. This system of crankcase ventilation circulates fresh air through the crankcase and carries the blowby gases into the intake manifold or air cleaner. Blowby is then drawn into the combustion chambers and burned with the air/fuel mixture. The system is called "Positive Crankcase Ventilation" because air is always circulated through the crankcase whenever the engine is running.

---

1. Whenever the engine is operating, blowby gases will be forced into the _____.

---

2. The gasoline vapors which are contained in the blowby gases contain mostly _____.

---

3. Hydrocarbon emissions must be controlled since they combine with NO_x in the presence of sunlight to form _____ smog.

---

4. Blowby gases contain gasoline vapors, corrosive acids and _____ vapor.

---

5. Before approximately 1960, a device was used to remove the blowby gases from the crankcase to the atmosphere. This device was called a _____ _____ _____.

---

6. Beginning in 1961 and used on nearly all automobiles manufactured after 1963, was a new crankcase ventilation system. This system is called the _____ _____ _____ system.

7. This new crankcase ventilation system has been abbreviated and called the _____ system.

SYSTEM/COMPONENT PURPOSE

You will recall from the introduction, the PCV system provides constant ventilation of the engine crankcase. Blowby gases contain the harmful pollutant known as HC or hydrocarbons. You will also remember that these blowby gases must be removed from the crankcase. The PCV system directs the blowby gases to the intake manifold or air cleaner for burning in the combustion chamber. The purpose of the PCV system is to constantly ventilate the engine crankcase and to prevent hydrocarbons from escaping to the atmosphere.

TYPE ONE PCV SYSTEM

There are four major types of PCV systems. The Type 1 system or "open" PCV system was used on most cars between 1961 and 1968. This system is called an open system because the breather cap leaves the crankcase open to the atmosphere. As can be seen in figure 1-3, the Type 1 or

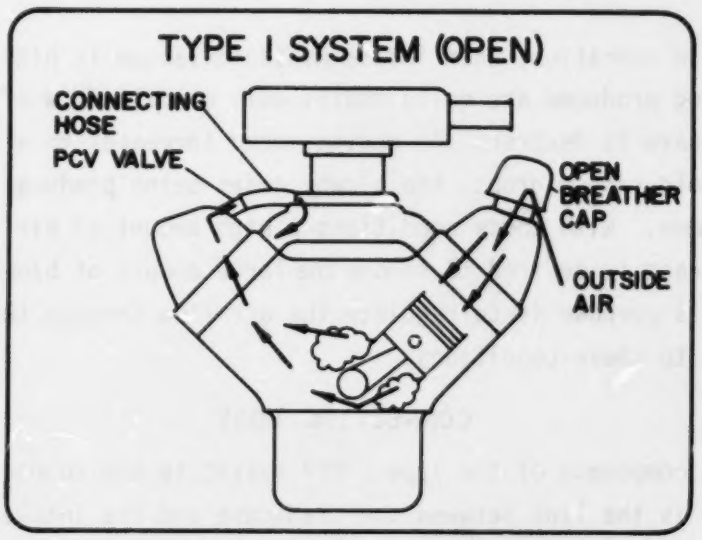

FIGURE 1-3

"open" PCV system has three major components. An open oil breather cap, a PCV valve and a connecting hose are used with Type 1 systems.

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OPEN OIL BREATHER CAP

The open oil breather cap used in this system serves as an open vent to allow air into the crankcase. This allows the crankcase to breathe, thus the name breather cap. During high speed, wide-open throttle operation , the intake manifold vacuum is low, crankcase pressures are high, and excessive blowby gases are produced. Under these conditions the PCV system may be unable to remove all the blowby gases. When this happens the breather cap will serve as an additional vent for the blowby gases to escape from the crankcase.

PCV VALVE

The PCV valve serves as the control unit for the crankcase ventilation system. Due to the changes in throttle opening during engine operation, the intake manifold vacuum will vary. If no valve was used with this change in vacuum, an unwanted variation in crankcase ventilation would occur. For this reason a regulating valve named the PCV valve has been used.

During idle operation, when intake manifold vacuum is high and the blowby gases being produced are quite small, only a small flow of air through the crankcase is desired. As engine speed increases to a higher speed and manifold vacuum drops, the blowby gases being produced will increase to a maximum. With these conditions a high amount of air flow through the crankcase is desired to remove the large amount of blowby gases. The PCV valve's purpose is to regulate the air flow through the crankcase according to these conditions.

CONNECTING HOSE

The final component of the Type 1 PCV system is the connecting hose. This hose is the link between the crankcase and the intake manifold. The PCV valve is usually located at one end of this hose.

TYPE TWO PCV SYSTEM

The Type 2 PCV system is much the same as the Type 1 system. This system was installed on some 1950 and early 1960 California cars which were not originally equipped with a PCV system. This system also has three major

components. A restricted oil breather cap, a West Coast Control Valve and a connecting hose are used.

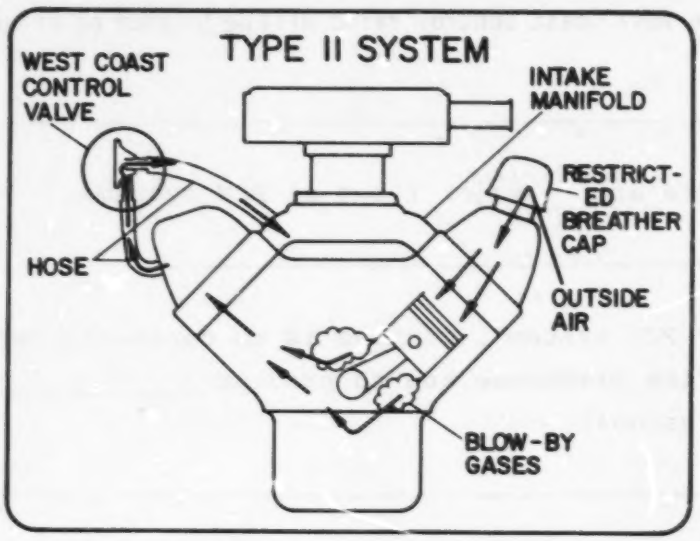

FIGURE 1-4

It may be seen in figure 1-4 that these components are connected in the same manner as those in the Type 1 PCV system. The purpose of these components is also much the same as those in the Type 1 system.

RESTRICTED OIL BREATHER CAP

The restricted oil filler cap serves the purpose of a vent to allow fresh air into the crankcase. It also provides a resistance to air flow to prevent blowby gases from moving out of the crankcase to the atmosphere.

WEST COAST CONTROL VALVE

The West Coast Control Valve's purpose is exactly the same as the PCV valve's purpose. It regulates the amount of air flow through the crankcase. This valve will allow a high rate of flow through the crankcase when an excessive blowby condition is present. When only small amounts of blowby are present in the crankcase the valve will permit only a small amount of air flow through the system.

CONNECTING HOSE

The last component in the Type 2 system is the connecting hose. This hose serves to link the crankcase to the intake manifold. As with the PCV valve, the West Coast Control Valve will be located at one end of this hose.

8. There are __ major types of PCV systems.

9. The PCV system's purpose is to constantly ventilate the engine crankcase and to prevent _____ emissions.

10. There are three components in the Type 1 PCV system. The most important component is the _____ _____ which regulates the amount of crankcase ventilation.

TYPE THREE PCV SYSTEM

The Type 3 PCV system is different from the first two systems discussed since it doesn't use a regulating valve. This system actually has only one component. A connecting hose runs from the crankcase to the air cleaner snorkel. This may be seen in figure 1-5. The purpose of this connecting hose is to link the crankcase to the air cleaner to provide a means for the blowby gases to escape from the crankcase. No component is used in this system to allow fresh air to enter the system.

The purpose of the Type 3 PCV system is to vent the harmful blowby gases from the crankcase. This system has been discontinued by American manufacturers but still may be found on a few foreign models.

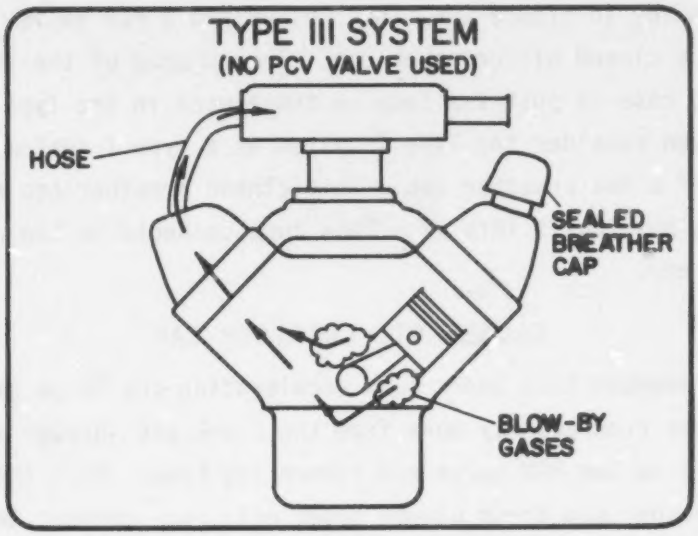

FIGURE 1-5

TYPE FOUR PCV SYSTEM

The Type 4 or "closed" PCV system is the system which has been used on all American automobiles since 1968. This system is called the "closed" system because the oil breather cap is closed off from the atmosphere. The components of this Type 4 system are the same as the Type 1 system with the exception of the oil breather cap.

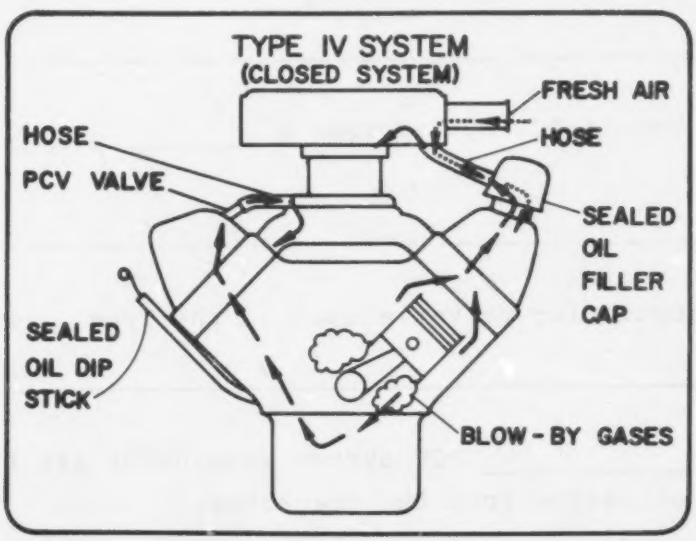

FIGURE 1-6

As you can see in figure 2-6, this system has a PCV valve, connecting hose, and a closed oil breather cap. The purpose of the valve and connecting hose is just the same as those used in the Type 1 system. You may even consider the Type 4 system as a Type 1 system with the addition of a new breather cap. This closed breather cap has a small connecting hose built into it. This hose connects to the air cleaner at its other end.

CLOSED OIL BREATHER CAP

You will remember that under hard acceleration the large amount of blowby gases produced may move from the crankcase through the breather cap as well as the PCV valve and connecting hose. With the use of the closed breather cap these blowby gases will pass through the small hose which connects to the air cleaner.

The purpose of the closed breather cap is to direct these extra gases to the air supply where they too can be burned in the combustion chamber. This allows the Type 4 or "closed" PCV system to ventilate the blowby gases from the crankcase and feed them back to the engine under all conditions. Now no blowby gases are allowed into the atmosphere. With the use of this closed system the entire HC emissions contributed by the crankcase have been eliminated.

---

11. The Type 4 PCV system uses a _____ oil breather cap.

---

12. No regulating valve is used in the Type __ PCV system.

---

13. The _____ PCV system eliminates all the hydrocarbon emissions from the crankcase.

SYSTEM/COMPONENT FUNCTION

You will recall from the last section that the Type 1 PCV system has three components. The most important component is the PCV valve itself. Now you will learn how and when this component works.

TYPE ONE PCV VALVE

The PCV valve is made up of the body, a spring, and the plunger or valve. It also has an opening at one end to be connected to the crankcase. The opening at the other end connects to the intake manifold connecting hose. The parts of the PCV valve may be seen in figure 1-7.

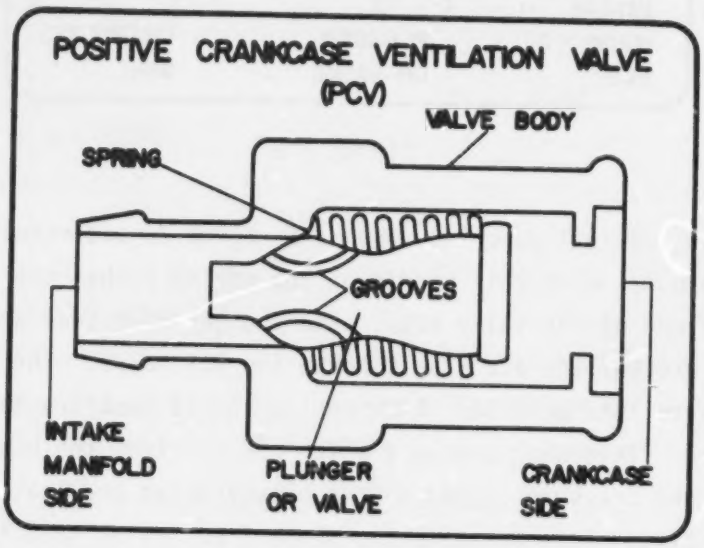

FIGURE 1-7

When the engine is operating intake manifold vacuum pulls the plunger against the spring. This will move the plunger toward the intake manifold end of the PCV valve body. The amount of plunger movement will change with any change in intake manifold vacuum. The higher the intake manifold vacuum, the more the plunger will move against the spring.

ENGINE OFF OR BACKFIRE

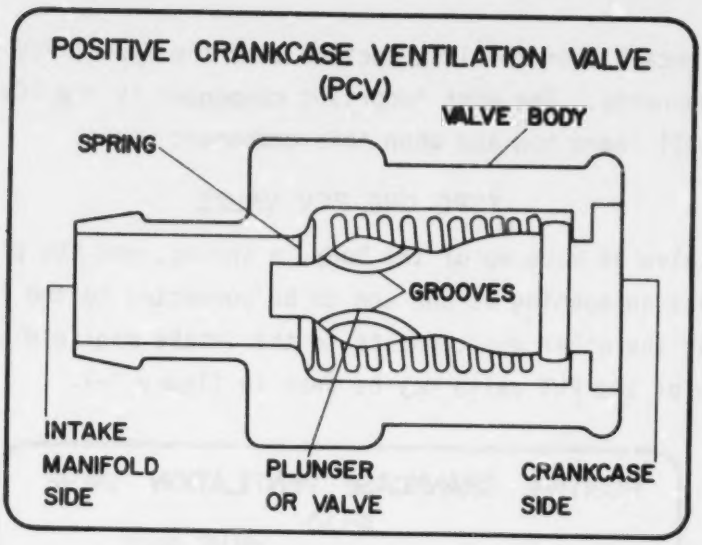

FIGURE 1-8

As you can see in figure 1-8, when the engine is not running there is no intake vacuum. With this condition the spring pushes the plunger to the crankcase end of the valve body. The plunger will seat against the valve body and prevent any air flow through the PCV valve. The plunger will also move to this position if the engine should backfire through the carburetor. This high pressure which results from the backfire will overcome the pressure caused by the blowby gases and seat the plunger in this position. This prevents the flame from moving into the crankcase and igniting the blowby gases.

IDLE OR LOW SPEED

When the engine is idling intake manifold vacuum will increase to a high value. This will pull the plunger to the intake manifold end of the valve. In this position the plunger will seat against the valve body. The air which is drawn through the crankcase will have to pass through the small idle grooves which are cut into the plunger. Since these grooves provide the only passages for air movement the amount of air circulating through the crankcase is small. You will remember that at idle only a very small amount of blowby gases are being produced.

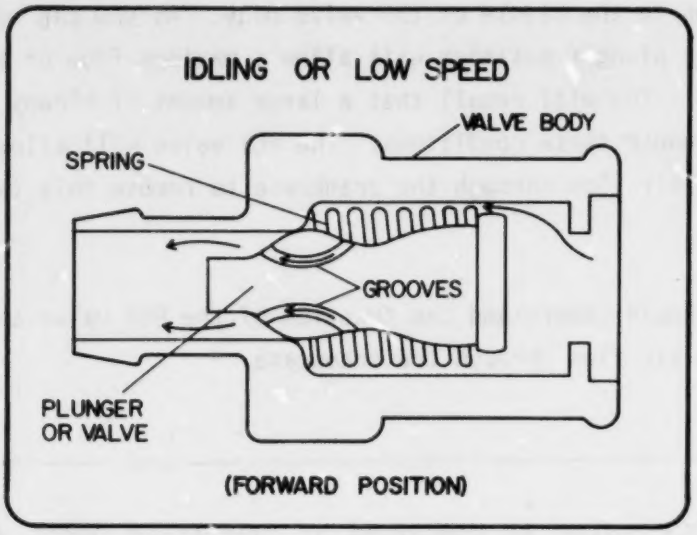

FIGURE 1-9

For this reason, only a small amount of air circulation through the crankcase is needed. This amount of air circulation will be set by the size and number of idle grooves cut into the plunger.

HIGHER SPEED

When the engine is accelerated to a cruise speed, intake manifold vacuum will decrease. With this condition the spring will push the plunger to

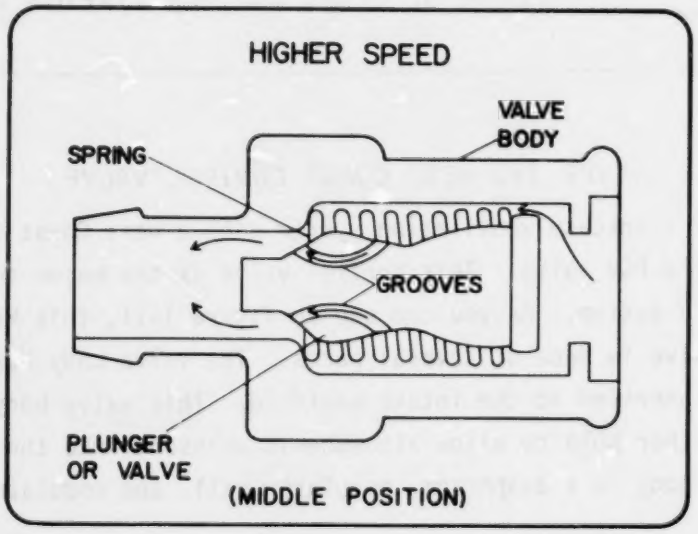

FIGURE 1-10

a position in the middle of the valve body. As you can see in figure 1-10, this plunger position will allow a maximum flow of air through the crankcase. You will recall that a large amount of blowby gases are produced under these conditions. The PCV valve will allow the correct amount of air flow through the crankcase to remove this large amount of blowby.

Now you should understand the function of the PCV valve and how it regulates the air flow through the crankcase.

---

14. A PCV valve is composed of the valve body, a spring, and the _____.

---

15. A _____ amount of crankcase ventilation is desired during periods of high engine speed.

---

16. Whenever the engine is operating at low speeds, a _____ amount of crankcase ventilation is desired.

TYPE TWO WEST COAST CONTROL VALVE

The Type 2 crankcase ventilation system uses a West Coast Control Valve instead of a PCV valve. This control valve is the major component in this Type 2 system. As you can see in figure 1-11, this West Coast Control Valve is made of several parts. The valve body has an opening which is connected to the intake manifold. This valve body also has a small breather hole to allow atmospheric pressure into the valve. Inside the valve body is a diaphragm, modulator ball, and modulator spring.

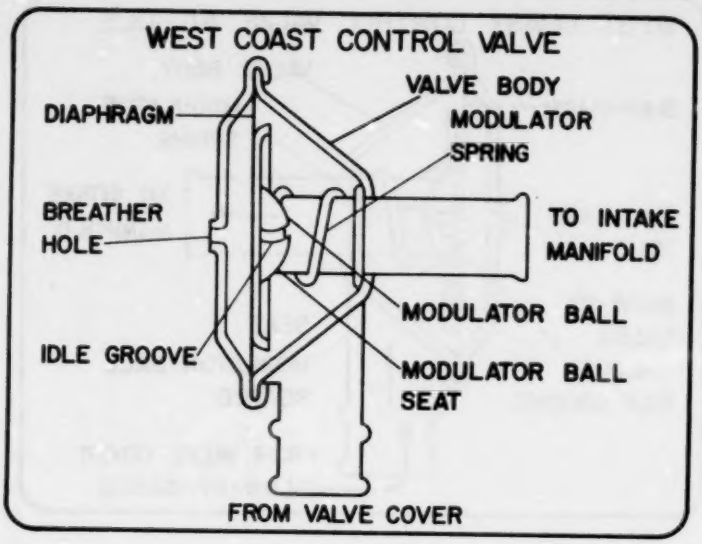

FIGURE 1-11

This system also uses a special restricted oil breather cap which plays an important role in the operation of the system. When the engine is off and no intake manifold vacuum is present the modulator spring will hold the diaphragm and modulator ball away from the modulator ball seat located near the intake manifold connection.

IDLE OR LOW SPEED

When the engine is started and allowed to idle the manifold vacuum will increase to a high value. This vacuum will draw air through the restricted oil filler cap. Due to this restriction and the presence of intake manifold vacuum, a crankcase vacuum will be created. This crankcase vacuum will act upon the diaphragm pulling it against spring pressure toward the modulator ball seat. When a high manifold vacuum is present the crankcase vacuum will also be high. This will pull the diaphragm against spring pressure until the modulator ball seats. In this position, as seen in figure 1-12, the air circulating through the crankcase must pass through the oil cap, then through the crankcase, and then through the small idle groove which is cut into the modulator ball. The ventilating air, containing the blowby gases, then passes into the intake manifold and into the combustion chamber for burning.

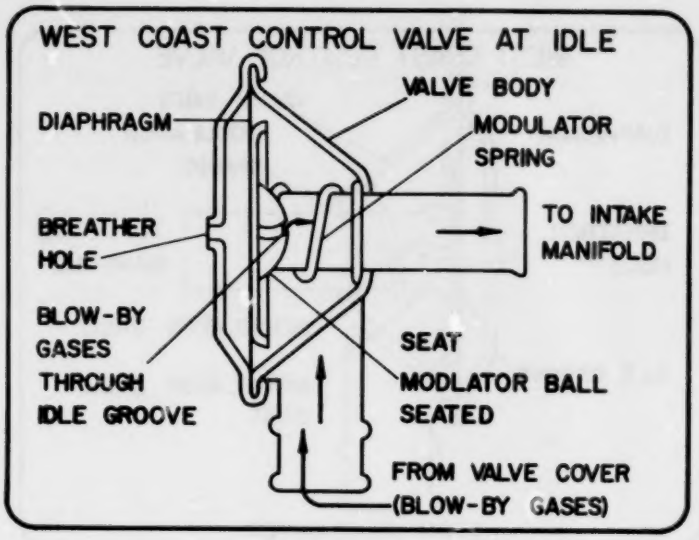

FIGURE 1-12

HIGHER SPEED

When the engine speed is increased to a cruise condition the intake manifold vacuum will drop. This will cause a drop in crankcase vacuum. As you can see in figure 1-13, this drop in crankcase vacuum allows the modulator spring to push the modulator ball off its seat. This will

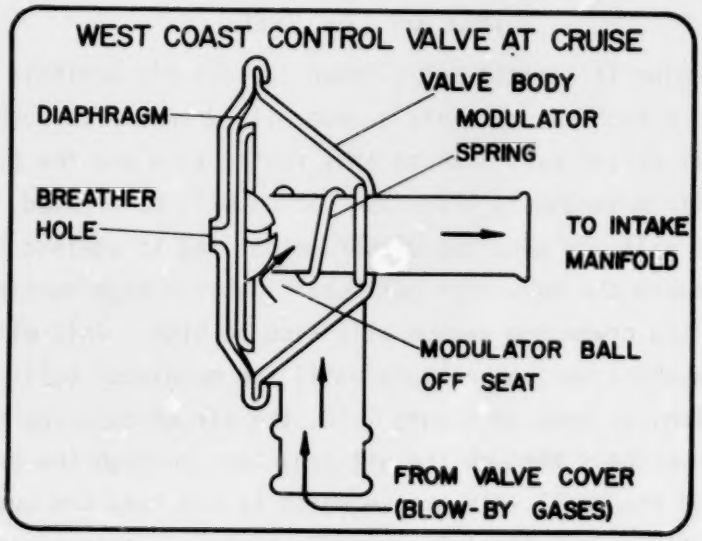

Figure 1-13

increase the effective opening between the intake manifold and the crankcase allowing a greater amount of crankcase ventilation.

The West Coast Control Valve will vary the amount of crankcase ventilation over a very wide range of driving conditions. This will allow the blowby gases to be vented from the crankcase only at the rate required. This in turn will prevent any excessive leaning of the air/fuel mixture entering the carburetor.

---

17. The West Coast Control Valve regulates the amount of crankcase _____.

---

18. The West Coast Control Valve will allow a _____ amount of ventilation at high engine speeds.

---

19. At low engine speeds the amount of ventilation will be restricted. The blowby gases will pass through the idle _____ which is cut into the modulator ball.

TYPE THREE PCV SYSTEM

The Type 3 system, you will recall, has only one hose which links the crankcase to the air cleaner. As you can see in figure 1-14, the blowby gases, which are escaping from the combustion chamber past the piston rings, create a slight pressure in the crankcase. Inside the air cleaner a slight vacuum condition is present. These two conditions, pressure in the crankcase and vacuum in the air cleaner, will act together to ventilate the crankcase. The blowby gases will move through the crankcase until the vacuum in the hose draws them into the air cleaner for burning in the combustion chamber.

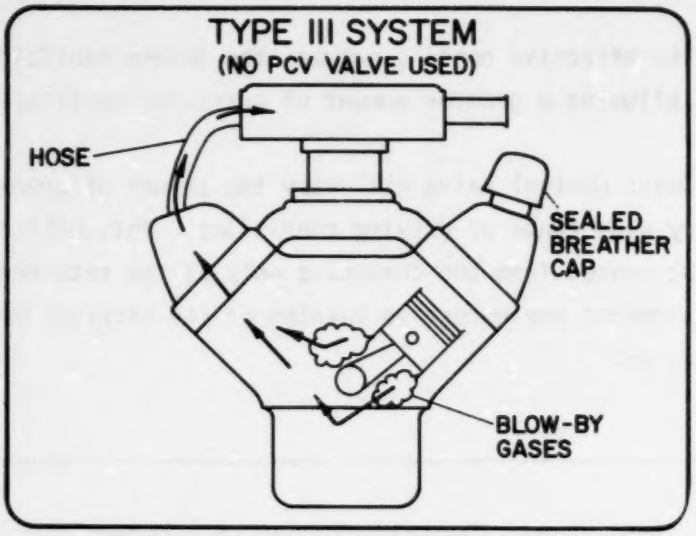

FIGURE 1-14

TYPE FOUR PCV SYSTEM

The Type 4 PCV system functions exactly the same as the Type 1 system. The PCV valve function will be briefly reviewed.

ENGINE OFF OR BACKFIRE

When the engine is off or a backfire through the carburetor has occurred the valve will be positioned as in figure 1-15. In this position the crankcase and the intake manifold will be closed from each other.

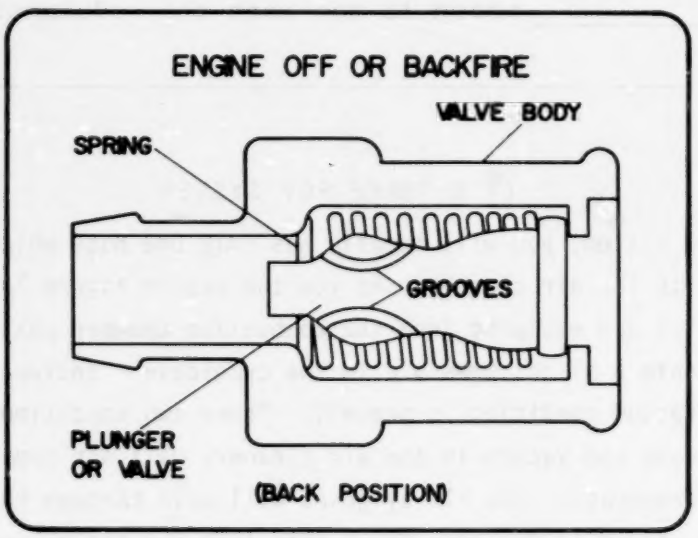

FIGURE 1-15

IDLE OR LOW SPEED

When the intake manifold vacuum is high, such as at idle, low speed or deceleration, the plunger will position itself as figure 1-16. This position will provide a limited amount of crankcase ventilation. You will recall that under these engine conditions only a small amount of blowby is produced.

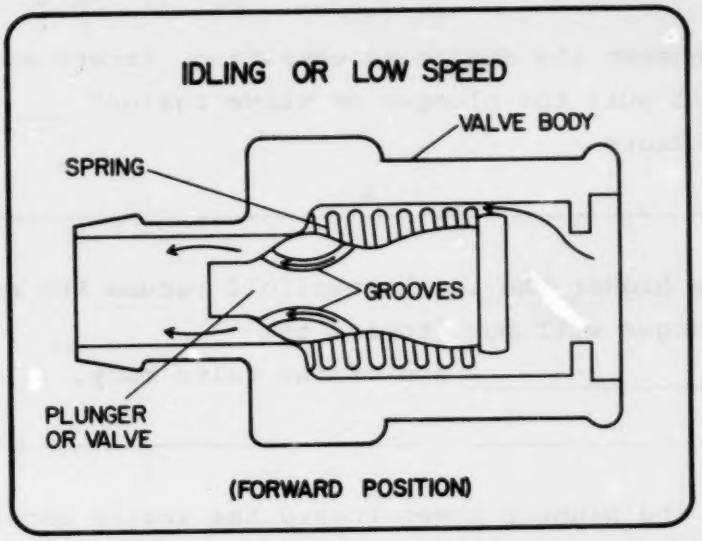

FIGURE 1-16

HIGHER SPEED

When engine manifold vacuum decreases during higher engine speed operation, the plunger will move to the position seen in figure 1-17.

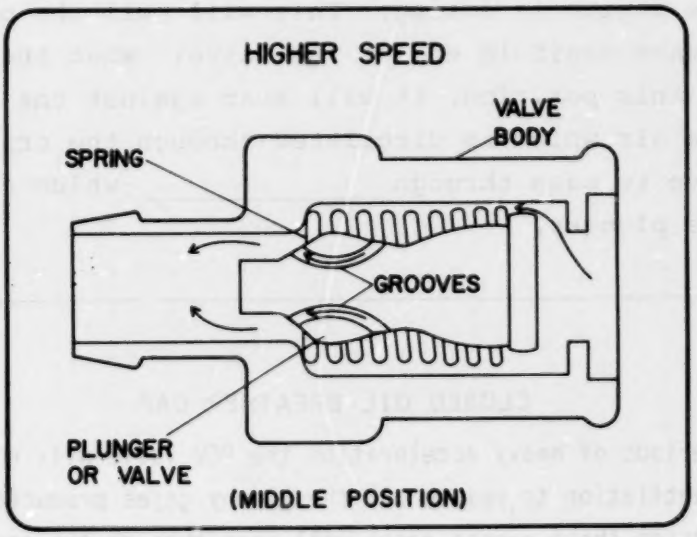

FIGURE 1-17

This will allow a maximum amount of crankcase ventilation to remove the large amount of blowby gases being produced.

---

20. Whenever the engine is operating, intake manifold vacuum will pull the plunger or valve against _____ pressure.

---

21. The higher the intake manifold vacuum the more the plunger will move toward the _____ _____ end of the valve body.

---

22. As the plunger moves toward the intake manifold end of the valve body the amount of crankcase ventilation will be _____.

---

23. Intake manifold vacuum increases to a high value when the engine is idling. This will pull the plunger to the intake manifold end of the valve. When the plunger is in this position, it will seat against the valve body. The air which is circulated through the crankcase will have to pass through _____ which are cut into the plunger.

CLOSED OIL BREATHER CAP

During periods of heavy acceleration the PCV valve will not provide enough ventilation to remove all the blowby gases produced. In an "open" system these excess gases will pass through the open oil breather

cap to the atmosphere. The "closed" or Type 4 system, however, uses a different oil filler cap.

The oil cap used on the Type 4 system has a hose connected to it. The other end of this hose connects to the air cleaner.

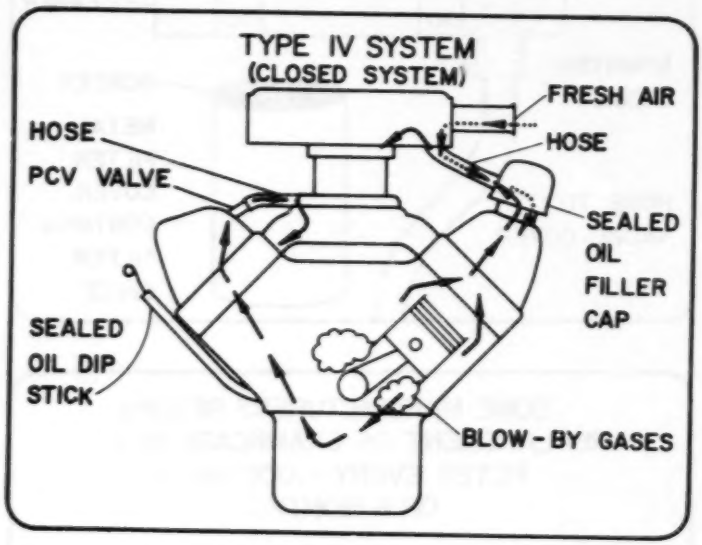

FIGURE 1-18

This may be seen in figure 1-18. During periods of normal operation the air needed to ventilate the crankcase is drawn from the air cleaner. During heavy acceleration the excess blowby gases will leave the oil breather cap through the connecting hose. These gases will now be burned in the combustion chamber as they mix with the incoming air in the air cleaner.

This system also has an additional filter in the air cleaner. A small gauze inlet filter is positioned where the hose and the air cleaner body meet. This may be seen in figure 1-19. This filter will clean the air entering the crankcase during normal operation. It also prevents any oil from entering the air cleaner during periods of heavy acceleration. Now it should be easy to see how the "closed" or Type 4 PCV system can eliminate all the hydrocarbon emissions from the crankcase.

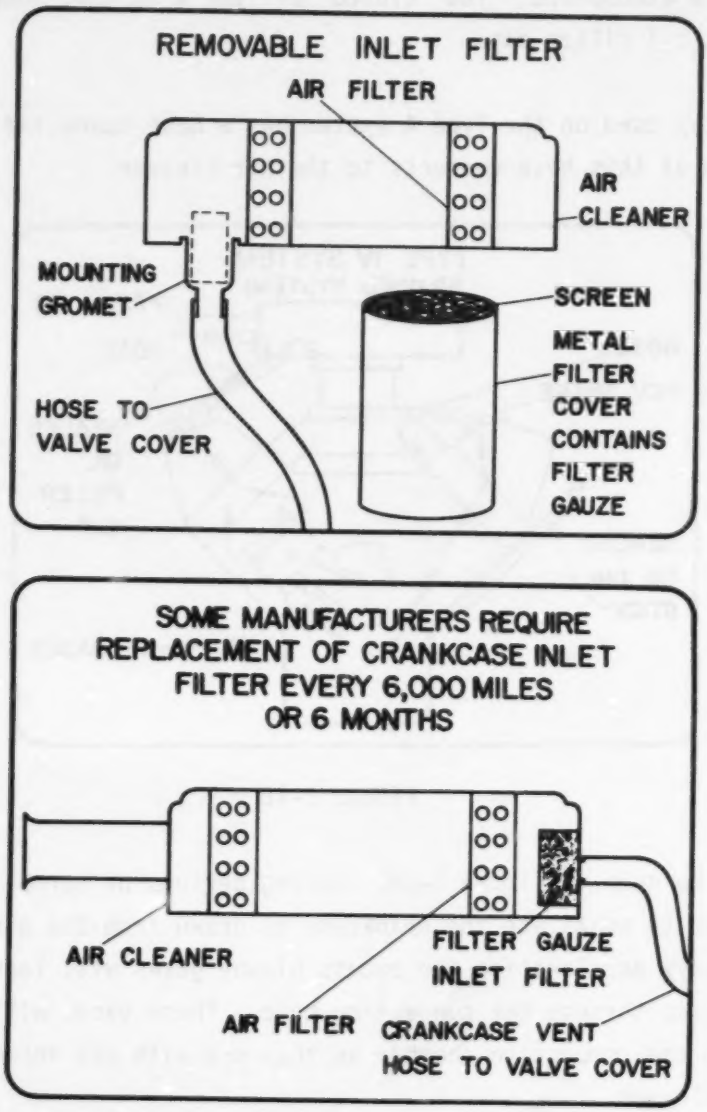
REMOVABLE INLET FILTER
AIR FILTER
AIR CLEANER
MOUNTING GROMET
SCREEN
METAL FILTER COVER CONTAINS FILTER GAUZE
HOSE TO VALVE COVER
SOME MANUFACTURERS REQUIRE REPLACEMENT OF CRANKCASE INLET FILTER EVERY 6,000 MILES OR 6 MONTHS
AIR CLEANER
FILTER GAUZE INLET FILTER
AIR FILTER
CRANKCASE VENT HOSE TO VALVE COVER

FIGURE 1-19

---

24. The Type 4 PCV system uses an additional filter located in the _____ _____.

---

25. The closed _____ _____ _____ is used to capture the excess blowby created during heavy engine acceleration.

SYSTEM INSPECTION

An inspection of the PCV system should be made periodically and prior to any testing of the system. This inspection will require no tools or instruments and takes only a few minutes. Many problems may be avoided or corrected by these steps.

1. Check to see that all components are properly installed on the engine and no modifications have been made. Air cleaner, oil breather cap, PCV valve and all hoses should be in place.

   In order for the PCV system to function as it was designed all components must be installed correctly. The air cleaner must be sealed and have no modifications and connecting hoses must be in place. The efficiency of the system will be reduced if any of these parts are missing.

2. Inspect all filters in the system. Air cleaner filter, oil breather cap filter, and the air inlet filter should all be inspected. If any of these are excessively dirty, clean or replace the filter.

   Excessive dirt in a filter will restrict air flow through the system. In order for the PCV system to operate efficiently no unnecessary restriction to air flow can be allowed.

3. Check the system connecting hoses for cracks, deterioration, and loose connections.

   Any air leaks into the system will reduce the PCV system's effectiveness. This condition may also lean out the air/fuel ratio delivered to the engine. Decayed or cracked hoses and hoses with loose connections will allow unwanted air into the system.

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4. Check to see if any large crankcase oil leaks are present in the engine.

   A large crankcase oil leak will decrease the ventilation through the crankcase. This condition if very severe may also indicate a restriction somewhere in the system. However, caution must be taken not to confuse this type leak with an oil pressure or main seal leak. A crankcase restriction would most likely be caused by a blocked PCV valve.

5. Last, a check of the air cleaner and air inlet filter should be made to see if excessive oil is present.

   This condition will also show a possible blocked PCV valve. Under this condition all blowby will escape from the crankcase through the air inlet tube. This will leave oil in the air inlet filter and air cleaner body.

---

26. Any large crankcase oil leak will cause a _____ in the ventilation through the crankcase.

---

27. The most probable cause of poor crankcase ventilation would be a blocked _____ _____.

SYSTEM TESTING

The PCV system should be tested periodically or anytime it is suspected of working improperly. Testing this system is relatively simple and requires little time to complete. Testing this system involves three separate tests - the RPM drop test, the simple vacuum draw test, and the vacuum draw test using an instrument.

RPM DROP TEST

The RPM drop test is the first test which should be done on the PCV system. The only tool needed for this test is a tachometer.

First the tachometer is connected to the engine. Allow the engine to reach normal operating temperature and record the engine speed or RPM. Next the air flow through the PCV system should be completely blocked. As can be seen in figure 1-20, this should be done by removing the PCV

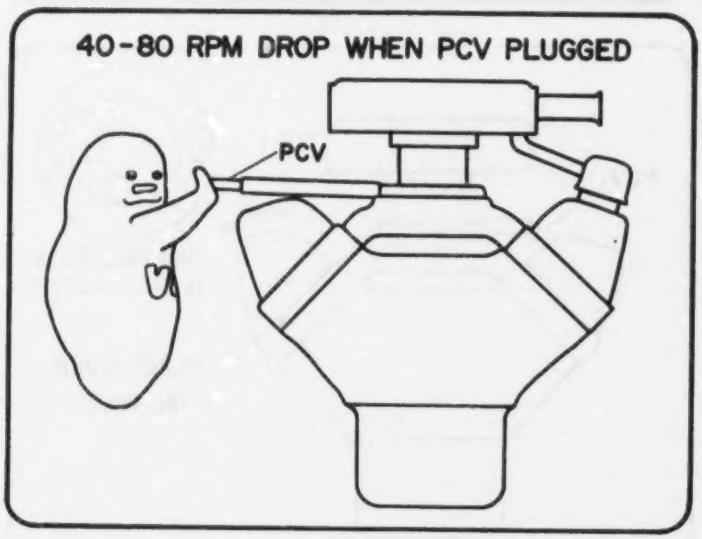

FIGURE 1-20

valve from the crankcase and holding a finger over the open end of the valve. Record the engine RPM with the PCV system plugged. The RPM should be 40-80 RPM lower than when the PCV system is fully connected. If no

drop in RPM is noted this is an indication of a blocked PCV system. This could be a blocked valve, hoses, crankcase passages or intake manifold passages.

VACUUM DRAW TEST 1

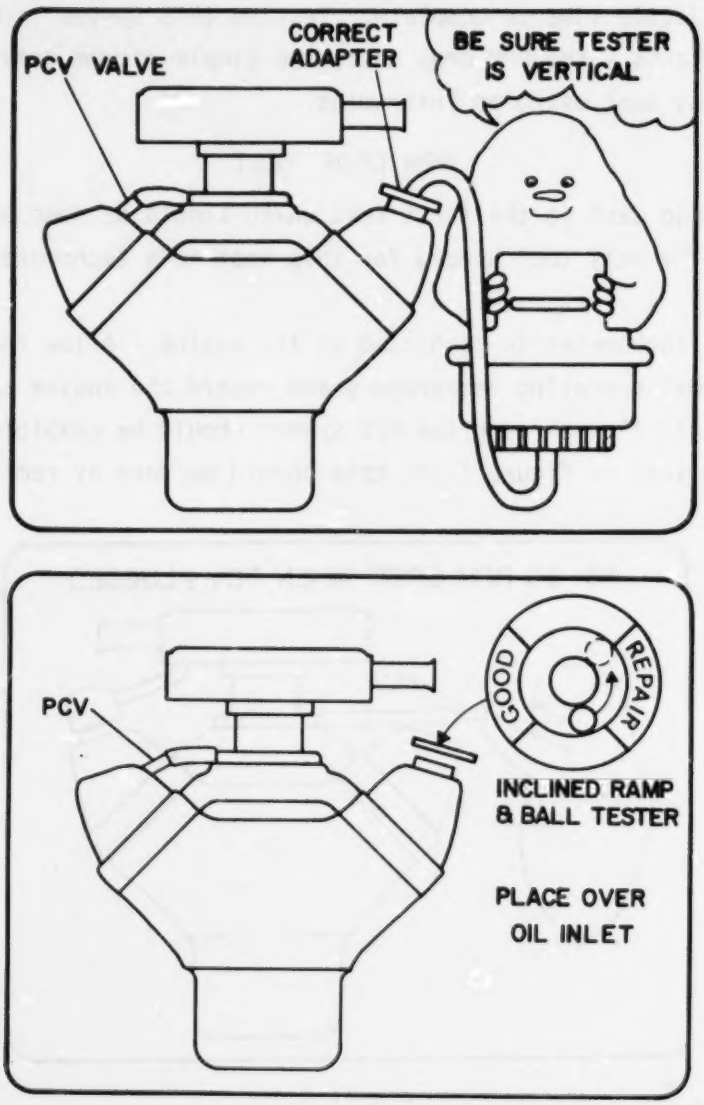

FIGURE 1-21

Next an instrument vacuum draw test should be conducted. This test should be conducted in two stages. A test of the entire system should be

made using either an adjustable PCV tester or an inclined ramp and ball tester. The engine should be brought to normal operating temperature. With the engine idling the tester should be placed over the oil filler hole as seen in figure 1-21.

If a weak vacuum is indicated on the tester the PCV system is not operating properly. This may be caused by poor engine condition or a plugged or malfunctioning PCV valve. To determine if the valve is operating properly it should be tested separately from the crankcase. This can be done using the adjustable PCV tester. Connecting the tester to the valve as shown in figure 1-22 will give an indication of the valve's condition.

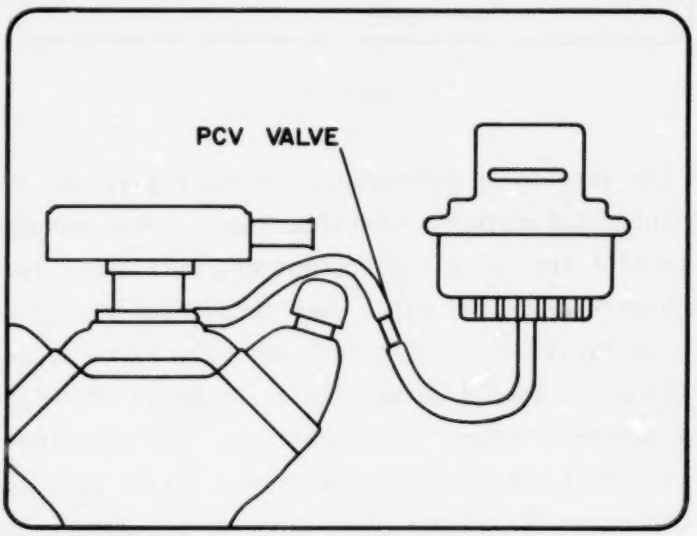

FIGURE 1-22

If the system test indicated a faulty system and the valve test indicated a properly functioning valve the engine is in poor condition.

VACUUM DRAW TEST 2

If neither of these test instruments are available a simple vacuum draw test may be performed. As with the previous test the engine is allowed to reach normal operating temperature. With the engine idling, place a piece of thin paper over the oil filler hole as shown in figure 1-23. The presence of crankcase vacuum will be indicated by the paper being drawn tight over the hole.

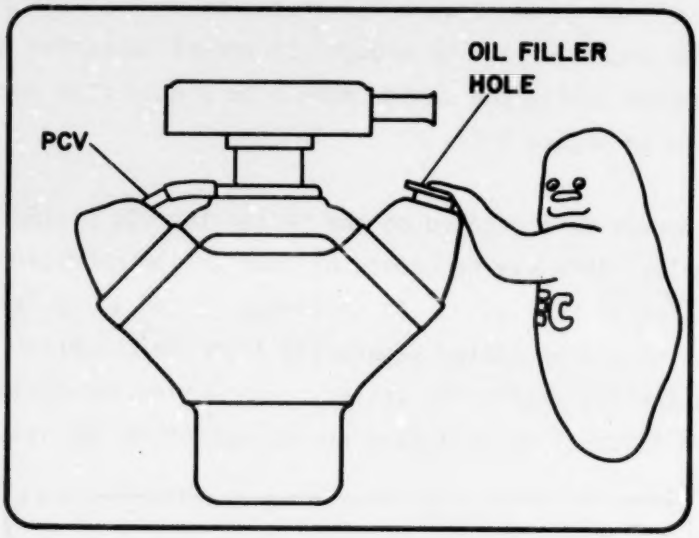

FIGURE 1-23

When doing any service or maintenance on the PCV system, it is important to consult the manufacturer's specifications. Most manufacturers require system inspection and valve replacement every 12,000 miles or 12 months. Check a good service manual since some manufacturers use PCV valves which last for up to 30,000 miles. In addition, all filters, oil caps, and other related parts should be serviced, inspected or replaced, when required by the manufacturer. In addition, specifications must be consulted for installing the proper PCV valve. Exact part numbers must be used when replacing PCV valves since many valves appear the same but allow different amounts of air to pass through the valve. Special PCV hose should always be used whenever this hose must be replaced, since the wrong hose may collapse causing the system to malfunction. Proper maintenance and servicing will assure that the PCV system continues to function as it was designed.

The proper operation of the PCV system aids long engine life and the reduction of hydrocarbon emissions.

28. The first test which should be performed on the PCV system is the _____ drop test.

29. Whenever the PCV hose must be replaced, special PCV hose should always be used since the wrong hose may _____ causing the system to malfunction.

30. A _____ draw test should also be performed when testing the PCV system.

31. The _____ _____ and air inlet filter require scheduled replacement.

SYSTEM SUMMARY

PURPOSE

The purpose of the PCV system is to reduce hydrocarbon emissions to the atmosphere. It also helps prevent oil dilution and sludge formation in the crankcase. This is done by directing blowby gases in the crankcase back into the combustion chamber to be burned in the normal combustion process.

MAIN COMPONENTS

Sealed Oil Filler Cap - Prevents escape of blowby gases to the atmosphere from around the oil filler cap during heavy acceleration.

Sealed Dipstick Cap - Prevents escape of blowby gases to the atmosphere from around the dipstick during heavy acceleration.

Air Intake Hose - Allows fresh air to enter the crankcase from the air cleaner.

PCV Valve - Composed of body, plunger, and spring, the PCV valve meters the flow of blowby gases from the crankcase back into the intake manifold by sensing intake manifold vacuum.

SYSTEM FUNCTION

Intake manifold vacuum draws blowby gases from the crankcase into the manifold to be consumed in the combustion chamber. The PCV valve plunger prevents blowby gas flow during engine off or engine backfire conditions. Blowby gas flow is regulated by the amount of intake manifold vacuum acting on the PCV valve spring and plunger.

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ANSWERS

1. crankcase
2. hydrocarbons
3. photochemical
4. water
5. road draft tube
6. positive crankcase ventilation
7. PCV
8. four
9. hydrocarbon
10. PCV valve
11. closed
12. three
13. type four
14. valve or plunger
15. large
16. small
17. ventilation
18. large
19. groove
20. spring
21. intake manifold
22. reduced
23. grooves
24. air cleaner
25. oil breather cap
26. decrease
27. PCV valve
28. RPM
29. collapse
30. vacuum
31. PCV valve

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